Interagency Process for Fish Screen Project Designs in California

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Introduction

Recently, interest in the design process for fish screen projects has propagated through various environmental management forums in California. Also, misunderstandings turned into confusion regarding the fish screening standards of the National Marine Fisheries Service, Southwest Region (NMFS-SW), the U.S. Fish & Wildlife Service (FWS), and the California Department of Fish and Game (CDFG). To address these issues, the following is a description of the government's interagency fish screening process and other important aspects of California's fish screen programs.

Fish Screens

Positive Barrier Fish Screens are currently the best available technology for the prevention of fish losses due to entrainment at water diversion sites. The operating principle of a positive barrier screen is simple: insert a permeable, physical barrier between the fish and the diversion point such that the fish remain in their natural habitat, not in the diversion. The screen itself is constructed of a durable material (e.g.-stainless steel) and features slotted, punched, or woven openings. Several screen panels or units may be combined in various configurations to obtain a composite system capable of passing large volumes of water. Screen openings are machined with precision, so that they are wide enough to pass water but narrow enough to physically exclude very small fish.

Over the past several decades, the positive barrier concept has proven most effective in preventing entrainment. Today's state-of-the-art screens offer a high degree of protection for fish. In fact, several recent evaluations of modern screens show efficiencies approaching 100% protection. These are instances where thorough site analysis, excellent design and engineering, and accurate construction practices resulted in superior performance. Unfortunately, there are other cases, particularly among older, outdated screens, where performance suffered because of design or construction errors. As a group, fish passage specialists have assimilated the lessons of the past to a large extent. The result of these learning experiences are tried and true fish screen standards which govern the design and construction process for all state and federal sponsored projects in California.

Project Identification

A fish screen project is typically identified when a project proponent voluntarily solicits government agencies for financial or technical assistance. In some cases, a project is initiated by a regulatory action. Such an action is typically triggered by other in-river activities which require statutory environmental review or permitting procedures (e.g.- dredging, new construction). When a fish screen project is identified, it is referred to the correct government agency, or interagency group, for administrative processing. Currently, most large screen projects are administered under the purview of the Anadromous Fish Screen Program (AFSP), while some medium and small scale projects are referred to NMFS, CDFG, the Natural Resource Conservation Service (NRCS), or other resource agencies.

Technical Advisory Groups

For most significant water diversion flows, fish screen project design involves interagency cooperation and oversight by a *Technical Advisory Group* (TAG). The TAG generally consists of government agency representatives, the project sponsors, and consultants from various disciplines as necessary. The TAG serves several functions: 1) it focuses a multi-disciplinary team's attention on the complicated issues of screen design and construction, 2) it provides a forum where technical issues are resolved, 3) it fixes project accountability on a definitive group of individuals, 4) it uncovers policy issues which cannot be resolved at the technical level, and 5) it offers a mechanism whereby high level policy issues are elevated to the appropriate decision making authority.

Fish Screen Design Considerations

For a typical fish screen project, the TAG must identify and resolve a wide range of design and construction issues. These often summon expertise in subjects such as hydraulic and mechanical engineering, biology, hydrology, construction, resource planning, and economics. Specific examples of common engineering design issues include: intake location, hydraulic characteristics, water quality, bed load transport, debris loads and sedimentation, temporal flow patterns, tidal effects, velocity distribution, diversion requirements, flood flows, screen mesh size, structural integrity, bypass system configuration, and screen cleaning systems. Added to this list are the many biological factors which must be accommodated by the engineering design: multiple species protection, temporal and geographical distribution of species, predation, swimming abilities of fry, downstream and upstream passage, migration windows, and many others. Finally, the TAG must synthesize this mixture of aquatic science, biology, and engineering with economic aspects of the project, i.e.- cost of facilities, funding mechanisms, and funding availability.

Fish Screen Design Process

Fish screen design usually proceeds in three discrete phases: 1) Preliminary Design, 2) Feasibility Design, and 3) Final Design.

Preliminary design is essentially a brainstorming session on the part of fish passage specialists where various design options are proposed and assessed for appropriateness to the site. Specific steps include: description of design requirements, data collection, site analysis, conceptualization

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of alternatives, engineering drawings, refinement, and alternative selection. Physical or numerical modeling may be employed to determine whether a specific design alternative can meet the design objectives.

Feasibility design takes the option selected from preliminary design and develops the concept to a point where criteria resolution, construction scheduling, and funding issues can be addressed. Commonly, feasibility reviews are performed somewhere between 30% and 50% of design completion. Detailed engineering drawings, prepared by an engineering consulting firm, are reviewed by government specialists within the TAG forum to ensure consistency with established design criteria. Many times this level of review will generate substantive improvements in the proposed design because the TAG represents a multi-disciplinary review team- offering diverse experiences that may be relevant to a unique part of the project.

Final design constitutes the culmination of the review process and signals official authorization for the construction phase. A final design review includes inspection of detailed drawings and engineering specifications, as well as construction bidding and contractual packages. Frequently, final reviews are held when the design is approximately 90% complete. This point provides an opportunity for the TAG to conduct a last round of review and comment, ensuring the project is on the intended course, and refinements from previous review sessions have been incorporated. Finally, when the engineering design firm presents the TAG with a 100% design package, all questions concerning the design should be answered, leaving only the formality of design acceptance and agency concurrence to be rendered.

Fish Screen Permit Process (Under development - to be designed to streamline permitting and provide assurances)

Fish Screen Funding Process

(Under development)

Fish Screen Criteria

The California Department of Fish and Game and the National Marine Fisheries Service promulgated formal fish screening criteria as a result of their public trust responsibilities (e.g.- protection of listed species under the state and federal *Endangered Species Acts*). These criteria provide both specific and general guidelines for design, siting, construction, and operations of fish screening facilities. Due to different fish protection mandates and histories, the design criteria of the two agencies evolved separately and with a slightly different focus. The National Marine Fisheries Service criteria, *Fish Screening Criteria for Anadromous Salmonids,* is distinctly targeted to salmonid species, but it effectively protects many other fish species as well. The California Department of Fish and Game's *General Fish Screening Criteria* was developed based on extensive swimming ability research conducted on several species of salmonids and American shad.

Historical Development of Fish Screen Criteria

The National Marine Fisheries Service, Southwest Region, produced *Fish Screening Criteria for Anadromous Salmonids* in response to diminishing salmon runs and subsequent listings under the federal Endangered Species Act. The agency's original fish screen criteria was developed by the NMFS Northwest Regional office (NMFS-NW), after a careful review of the scientific literature which related to salmonid swimming ability. The definitive research, *Salmonid Fry Swimming Ability Data for Diversion Screening Criteria* (Smith and Carpenter, 1987), was performed at the University of Washington Fisheries Research Institute. The study determined the maximum short term swimming stamina of five species of salmonid fry at the swim-up stage of development. Testing salmonids at this immature stage simulated a worst case scenario for fish encountering a diversion screen. The research featured a comprehensive literature review, elaborate experimental design, and rigorous statistical analysis. The species tested included pink, chum, chinook and coho salmon, plus two stocks each of rainbow and steelhead trout.

The California Department of Fish and Game developed *General Fish Screening Criteria* after conducting several years of swimming ability research for the proposed Peripheral Canal Project, which would require a fish screen of unprecedented proportions. The most often cited study in support of the CDFG criteria is *Responses of Juvenile Chinook Salmon, Oncorhyncus tshawytscha, and American Shad, Alsosa sapidissima, to Long Term Exposure to Two-Vector Velocity Flows* (Kano, 1982). The study, commonly referred to as the "treadmill," tested swimming responses of young-of-the-year chinook salmon and American shad to two-vector flow conditions. A few of the notable differences between the "treadmill study" and the Smith and Carpenter study were: 1) the treadmill did not test as many species of salmon as Smith and Carpenter, but did test a different species, American shad, 2) the treadmill simulated effects of two vector flows, i.e.- combined approach and sweeping velocities, while the Smith and Carpenter study tested one dimensional laminar flow, and 3) the treadmill tested swimming behaviors in both dark and lighted conditions, while Smith and Carpenter tested fish only in the light, at different water temperatures.

Both swimming ability studies (Smith and Carpenter, 1987; Kano, 1982) generated essential information on which to base screen criteria. However, NMFS-NW and CDFG drew somewhat different interpretations from their respective research, resulting in criteria which could be applied to each agency's species of concern. Based on the interpretation of the Smith and Carpenter research results, NMFS established two of its most important screen criteria parameters: approach velocity (0.4 feet per second) and screen exposure time (60 seconds). NMFS-NW selected these parameters by analyzing the data sets and choosing values where the weakest swimming fish of all species did not cease swimming, thus providing near 100% protection. Based on the outcome of the treadmill research, as well as previous studies by the Interagency Ecological Program (IEP), CDFG concluded that an approach velocity of 0.33 fps was sufficiently low to protect species of concern in California without juvenile bypass systems, regardless of exposure time.

"Exposure time," or the amount of time a fry-sized fish must encounter an entrainment velocity along the face of a fish screen, was widely debated for certain screen sites in California over the past decade. A strict interpretation of the NMFS exposure time criteria often prescribed an expensive juvenile bypass system as part of the overall system design, whether it was the most cost effective solution for a specific diversion site or not. What went unnoticed, however, was NMFS willingness to negotiate the best screening solution on a case-by-case basis with its peers at the Technical Advisory Group level.

To complicate matters further, concern about multiple species protection has increased. In the treadmill study, American shad were found to be good swimmers in lighted conditions, but were susceptible to impingement during darkened conditions at approach velocities greater than 0.2 fps. Also, delta smelt have been shown to be relatively weak swimmers compared to other species. The U.S. Fish & Wildlife Service, therefore, stipulates an approach velocity criteria of 0.2 fps in areas of the San Francisco Bay where delta smelt are present. It is situations like these that point to the need to expand our collective knowledge about swimming abilities of different species. At present, a major IEP fisheries research project is being conducted at the University of California at Davis. This research is an updated version of the original treadmill design and will feature stamina and behavioral tests on some new species of concern. It is hoped that the "Treadmill II" studies will yield a greater understanding of what is still an inexact science, but the need for additional research is evident.

What is the answer to the screen criteria question? It is clear the resource agencies developed different criteria for different reasons, but this does not necessarily mean fish are protected better by one criteria or the other. Instead, it means that, depending on site specific circumstances, one set of criteria may be more appropriate to a particular screen design than another. Additionally, all the resource agencies selected their criteria values conservatively- so there is a comfortable margin of safety when it comes to actual risk of screen impingement. Nevertheless, differing interpretations of swimming ability research combined with unique site applications were previously at the heart of the screen criteria debates in California. Fortunately, they also provided the answers to a common sense, compromise solution.

Resolving Fish Screen Criteria Issues

Although some philosophical differences still remain between NMFS-SW and CDFG with respect to fish screening, it is largely a non-issue because of continuing cooperation between the fish passage specialists and engineers in each agency. These technical experts meet regularly to discuss current screen design projects and fundamental fish screening issues. Through this system of communication and cooperation, solutions to major criteria differences have been found for all existing screen projects in California. Furthermore, the screen criteria of each agency has flexible language so that specific criteria such as approach velocity or exposure time can be modified (at the technical review level) if unique site conditions warrant a variance.

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Recently this practice has proven successful in the design of two large fish screens for Reclamation District 108 and Reclamation District 1004. In both cases, NMFS accepted a more stringent approach velocity standard for a design without intermediate juvenile bypasses. The reasoning was based on a site specific opportunity for maximum fish protection: a larger, lower velocity screen- enabling fish to remain in the Sacramento River- was deemed preferable to a smaller, higher velocity screen with a single, intermediate bypass. Even the GCID criteria disputes, hotly debated for several years, were resolved in this fashion. Hence a system is in place to accomplish successful fish screen design. Meanwhile, federal and state fish screen specialists continue to work for greater levels of consistency and understanding.

In March 1996, a "Fish Screen Criteria Summit" took place in Ashland, Oregon. The meeting brought together fish passage experts from California, Oregon, and Washington for the purpose of resolving screen criteria disputes. In that meeting, a conceptual framework was developed for resolving California's criteria differences. An action plan was initiated. According to the Ashland plan, an in-depth review of the landmark research and scientific literature was performed. This involved computer searches for existing scientific information, requisitioning numerous studies from the northwest, and searching the Fish and Game archives in Stockton for old records of "treadmill experiment." Next, all available information was re-examined and put it in historical context. A peer-level debate ensued for months. When details of the conceptual framework were finally agreed upon, new language was crafted to incorporate necessary changes while simultaneously maintaining consistency with traditional criteria. This was very challenging, but after numerous internal reviews, NMFS-SW Region and California Department of Fish and Game each revised its criteria to satisfy the unique screening situations in California. As of April 1997, the revised criteria of both agencies are compatible. These historic changes will put to rest the old debates, since the major elements of NMFS-SW and CDFG fish screening criteria are now consistent.

Conclusion

There are over 3000 documented, unscreened water diversions in the Central Valley, and many more throughout the state of California. Each unscreened diversion can potentially entrain, and ultimately kill, fish of many different species. By building state-of-the art fish screens, we can save hundreds of thousands of migrating juvenile fish each year, while enjoying our water resources for other uses at the same time. Fish screens are not a panacea, however. By themselves, they do not solve the problem of dwindling fisheries stocks completely. Yet fish screens are a major step toward the ultimate solution. And since the technology is available, they can be built at every water diversion site to protect entire schools of vulnerable, young fish from the threat of entrainment.

California's Fish Screening Programs are gaining momentum and support from both the public and private sector. Everyone realizes we must act cooperatively to fulfill our common environmental stewardship responsibilities. In this regard, strong public-private partnerships are key. These partnerships need nurturing, however, since many of the required alliances are nontraditional. But, as we go down this road of fisheries restoration, let us bear in mind what is at stake- the natural resources heritage of our children. Fish screens offer a win-win solution to environmentalists and diverters alike. With effectively screened diversions, water users get the water they need AND the fish are protected. We cannot afford to pass up a proposition like that.